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Environmental Degradation and the Demand for Children

Searching for the Vicious Circle

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Lant Pritchett

Because of the important role that children play in collection activities, the demand for children may increase as local environmental resources are depleted, setting up a vicious circle between resource depletion and population growth. Analysis of household data from Pakistan yields some support for this hypothesis, although the effect may be small and dependent on endogenous local property rights.

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Summary findings

Filmer and Pritchett explore the hypothesis that — because of the important role children play in collection activities (firewood, water, grazing) — the demand for children may increase as local environmental resources are depleted, setting up a vicious circle between resource depletion and population growth.

Using a large-scale household data set from Pakistan, with detailed information on fertility and the allocation of time (of women, children, and adults) to collection activities, they find that:

- Collection activities absorb a substantial part of household resources. Firewood collection accounts for 6.2 percent of household expenditures, valued in collection time.
- Collection absorbs a quarter of the time of children.
- Women benefit when there are older children in the household. They work 2.6 hours a week less in household activities for each child aged 10 to 15, and 3.2 hours less for each child over 15.
- There seems to be a relationship between fertility and the availability of firewood. Even after controlling for other determinants of fertility in reduced form regressions, they show that households that live some distance from firewood have more children whereas households that live where firewood is more expensive have fewer children.

This paper — a product of the Poverty and Human Resources Division, Policy Research Department — is part of a larger effort in the department to investigate the social and environmental consequences of growth-oriented policies. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Sheila Fallon, room N8-030, telephone 202-473-8009, fax 202-522-1153, Internet address sfallon@worldbank.org. July 1996. (50 pages)

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Environmental Degradation and the Demand for Children: Searching for the Vicious Circle

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Environmental Degradation and the Demand for Children: Searching for the Vicious Circle[1]

As environmental degradation and population growth have come to the fore of the development agenda, so too have beliefs and theories that suggest that problems of poverty, population, and the environment are inter-linked. In particular, some have proposed that environmental degradation and population growth may exacerbate one another in a vicious circle in which greater population leads to a worsening environment and a worsening environment leads to more rapid population growth (Dasgupta, 1995, Cleaver and Schreiber, 1995). One half of the vicious circle may seem obvious, that greater population in a given area leads to pressures on, and ultimately degradation of, the natural resource base: soil quality, water, grazing areas, wood availability[2].

The explanation of the second half to the vicious circle, that greater environmental degradation leads to increased population growth, is less straightforward. Most conventional

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[1] We would like to thank Kenneth Chomitz, Lawrence Goulder, the seminar participants of the Environmental Policy Forum at Stanford University and the Advisory Committee for the research project, "Social and Environmental Consequences of Growth-Oriented Economic Policies" for helpful comments. We would like to gratefully acknowledge funding from the research project.

[2] This proposition is not at as obvious as it may seem: some elements of the natural resource base, particularly the soils, may be under a regime of property rights such that an increase in population density, given the right policy, leads to higher prices and increased investments such that soil quality increases with greater population density. A recent study of the Machakos district of Kenya from 1930 to 1990 shows that a five-fold increase in population lead to no degradation (and possibly improvement) of soil quality, as farmers invested in terracing and other agricultural improvements (English, Tiffen and Mortimore, 1994).

theories suggest that greater natural resource scarcity should lead to a lower demand for children and slower population growth, both through the direct effect of lower income in reducing demand and because the scarcity of resources reduces the productivity of children as household producers. In this case the fertility response to environmental degradation mitigates, rather than exacerbates, environmental problems[3].

What is the behavioral mechanism that would produce a vicious circle? Greater environmental degradation could lead to increased population growth if increased scarcity of natural resource goods leads to a higher relative value of children. This is possible if children's comparative advantage as household producers is the acquisition of natural resources for which the family does not incur the full cost (for example, the collection of firewood, fetching of water, or grazing of livestock on open access land). It is possible this increase in the relative value of children from increased scarcity of available environmental goods could outweigh the income and productivity effects from privately owned resources and lead to a higher demand for children.

This paper empirically examines the links between children and the environment using data from the 1991 Pakistan Integrated Household Survey (PIHS)[4]. This survey is particularly valuable in that it contains four types of data relevant to the vicious cycle which are rarely found together; a) detailed information about the use of firewood and other energy sources (including their

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[3] Although this is not to say the fertility response will be sufficiently strong to avoid either a Malthusian low level equilibrium or worse, an environmental crisis, in which population pushes the natural resource base beyond some "breakdown" point, or especially a degradation of specific parts of environment resources such as biodiversity. Negative (or mitigating) feedback only implies the likelihood of these outcomes is decreased, not increased, by individuals' fertility responses.

[4] A detailed description of the survey methodology for this data is in World Bank (1995) and of this and other similar Living Standard Measurement Study surveys in Grosh and Glewwe (1995).

sources), b) time allocation data for children, c) fertility data, d) household characteristics, particularly including total expenditures. Pakistan is chosen for study because the existence of this rich data set[5].

The paper first briefly reviews the theoretical work on the existence of a vicious circle. The second section examines five facts relevant to vicious circle theories with the Pakistani data and shows that while some elements of the story hold, others are more problematic. The third section estimates the association between various measures of firewood scarcity and the fertility behavior of rural Pakistani women.

I) A vicious circle: A theoretical story

There are two strands to the theoretical literature on a vicious circle between population and environmental degradation. The first strand examines the consequences a vicious circle, if one were to exist. The second presents household models of fertility determination that suggest there might indeed be a vicious circle.

Nerlove (1991, 1992) examines the possible consequences of the existence of a vicious circle, defined as a two equation dynamic system relating environmental degradation (ED) and population (N):

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[5] The reader should feel free to insert here the joke about the drunk looking under the streetlight for his keys that he lost elsewhere because there was light. We admit Pakistan is the country being examined only because Pakistan is the country for which we have household income, fertility, and child time use data along with extensive data about firewood use and collection. Future research plans to examine the same issues in Nepal.

$$ED = g(N) \quad , \text{ where } \partial g(\ )/\partial N > 0$$

$$N = f(ED) \quad , \text{ where } \partial f(\ )/\partial ED > 0$$

This merely states mathematically that an increase in population (N) causes the environment to deteriorate (ED) while a deterioration in the environment causes population to increase. Nerlove works out the implications of this simple dynamic system. As with any non-linear system without stabilizing (and in this case with destabilizing) feedback mechanisms, the dynamic implications are both complicated and far from pretty.

In the Nerlove papers, however, the existence of a vicious circle is only asserted as a possibility. Nerlove's justification for this assertion is:[6]

> For example, as forests recede up the mountain sides, parents may perceive a greater benefit of having an additional child to gather firewood. More realistically, in a poor agricultural setting lower quality environments may be associated with a greater livestock component in total production. [...] Arguably, children have a comparative advantage over adults in tending livestock in contrast to the heavier labor of planting, tilling and harvesting crops. Thus, environmental deterioration may well enhance the marginal productivity of children, at least relative to family productivity.

Dasgupta (1993, 1995) and Dasgupta and Maler (1995) also develop theories with similar reasoning: that children are devoted to that part of family income which is derived from the exploitation of natural resources for which the primary cost is the time required to collect the good. Hence, as the implicit price of those goods goes up, the marginal value product of children relative to adults rises. Parents then may have the incentive to have more children in spite of the

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[6] Nerlove also gives a rationalization of environmental impacts on fertility through increased mortality. However, the rationale in this case is much less clear cut as while increased mortality may plausibly lead to increased fertility, whether this leads to increased population depends on a greater than one for one fertility response, which is empirically debatable.

worsening environmental conditions, and in spite of the fact that an additional child might further worsen these conditions for all other families.

There are two distinctive features of the vicious cycle story versus the more conventional theories of fertility. First, they emphasize that a significant part of household income, properly measured, is generated by activities that use natural resources for which the cost is not fully internalized by the household[7]. Second, they emphasize that children as workers are not like adults, but are relatively specialized in these natural resource related activities.

This paper will *not* elaborate a fully specified model of rural household behavior which simultaneously endogenizes all the relevant household decisions (which would have to include the allocation of household members' time across activities, the decision to purchase or collect goods, and fertility behavior). Our much less ambitious objective is to explore various empirical elements of the vicious circle story. Before attempting to estimate the association between firewood scarcity (as one indicator of the environment) and fertility, the next section examines five factual questions relevant to the plausibility of the vicious circle versus more conventional stories.

II) The vicious circle facts

The answers to the following five questions will help determine whether the interaction with environmental factors is likely to be important for fertility decisions:

- *How important are collected goods in household resources?*

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[7] This awkward circumlocution is the result of avoiding the familiar terms like "private property" or "commons" as in general the pattern of use and transfer rights over particular local natural resources are very much more complex than either of these paradigmatic cases and are endogenously determined, not given.

- *Is firewood collected from open access or common property sources?*
- *Are children relatively devoted to collection activities?*
- *Does the presence of children alter adult's time use?*
- *Do rural families alter their firewood use and collection activities in response to the presence of children?*

How important are collected goods relative to household resources? The collected good about which we have the most information, and which is relevant to environmental degradation, is firewood. Firewood is by the far the predominant fuel of households in Pakistan, especially in rural areas. Biofuels account for 86 percent and woodfuels alone account for 54 percent of all fuel use by households.[8] Ninety percent of rural households use some firewood, with some regional variations, less in the more developed Punjab and more in the more remote regions (table A1.1). The primary uses of energy by households are for cooking, 78.5 percent of use, and heating, 13.2 percent (table A1.2). Households use significant amounts of firewood on a daily basis. Among those households that use firewood the mean (median) level of firewood use is 5.8 (5) kg per day per household in urban areas, and 7.4 (6) kg per day per household in rural areas (table A1.4)[9]. These values vary somewhat across regions, with much higher consumption in

[8] As measured in the Pakistan Tonne of Oil Equivalent, which differs slightly from the international standard, Ouerghi and Heaps (1993)

[9] These figures are consistent with results other from smaller surveys cited in Ouerghi and Heaps (1993). These found for example, 6.9 kg in a survey of 197 rural households in northern Pothowar Plateau and 7.8 kg from 119 households in rain fed areas. Figures based on actual consumption are significantly higher than other estimates of consumption based on "needs" requirements, such as a commonly cited 2.8 kg per day estimate based on cooking and heating requirements.

Baluchistan, where rural household consumption is 10 kg per day versus only 5 kgs per day for rural Punjab.

Households obtain firewood either through collection or purchase. The vast majority of urban households exclusively purchase firewood (80 percent), so for the remainder of the paper we will focus on rural households. Most rural households either only collect (64 percent) or combine purchasing and collecting (11 percent), which does leave a significant fraction of rural households (25 percent) that only purchase firewood (table A1.5). These shares vary significantly across regions, with the highest share of collection only being in the Sindh region (76 percent) and the lowest in Punjab region (50 percent). The degree of collection varies across expenditure groups: the poorest 50 percent of households in the Singh region has a share of collection of 82 percent, and that in the Punjab region has a share of collection only of 59 percent[10].

As part of their study of household energy consumption in Pakistan, Ouerghi and Heaps (1993) calculated the value of collected firewood both at market prices, and by valuing the time that entered into the collection activity (table 1). When labor time devoted to collection activities is valued by setting the male wage rate at 4 rs per hour, and female and child time at half that, the value of collected firewood is quite close to its value if purchased in the market.[11] This should

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[10] That is, the poorest 50th percentile as measured by household expenditures per person. This number is calculated for all rural areas, and then for each province separately.

[11] The median reported daily male wage in the PIHS sample is 40 rs per day while the median female wage is 25 and the median child wage is 20. Since employment opportunities for females are quite limited and female and child labor cannot be separated in this exercise, Ouerghi and Heaps' assumption of half the male wage undervalues female time but is a good first approximation.

not be surprising as many households both purchase and collect firewood and hence are likely to be near the margin of indifference between the two.

Table 1: Value of collected firewood in rural areas.

	Number of collectors		Time required, person hours per year	Average distance to source of firewood	Labor cost of collection (rs/year) (at various valuations of time)		Value of collected wood at market prices (rs/year)	Labor cost of collection (valued differently for males, females and children) as fraction of median HH expenditures
	Adult male	Other			All labor valued at male wage	Male, female and child labor valued differently		
All Pakistan	.91	1.36	699	1.78	2797	1958	2099	6.2%
Punjab	.95	1.28	523	1.64	2092	1491	1752	5.2%
Sindh	.79	1.60	1044	1.76	4176	2778	2233	8.8%
NWFP	.99	1.26	760	1.75	3040	2188	2920	5.4%
Baluchistan	.75	1.41	1091	3.79	4364	2939	2819	7.9%

Source: Adapted from Ouerghi and Heaps (1993). Based on consumption of about 6 kg per household per day. The assumed wage rate for male time is 4 rs per hour. For female and child time the wage is assumed to be 2 rs per hour. Collected wood is valued at .80 rs/kg (as opposed to .98 rs/kg the average market price) to account for lower value of collected versus purchased wood.

The median total value of expenditures per household (including imputations for housing and firewood and other non-marketed production) in rural areas in Pakistan was 31,427 rs per year[12]. This implies that the imputed value of firewood is 6.2 percent of total typical household expenditures. This aggregate figure of course masks great variations, as in cases where firewood is scarcer or more distant it obviously consumes a larger fraction of income. For instance in Baluchistan, where distance to firewood is more than twice the national average, the value of

[12] Since the average exchange rate was 23.8 rs/$ in 1991 this is US$1,320 per household and since average household size is about 7, the median per person expenditure in rural areas in dollars would be US$189.

collected firewood is almost 8 percent of total household expenditures. Obviously there are also large fluctuations within these large regions.

Is firewood collected from open access or common property sources? A crucial element of the vicious circle hypothesis is the divergence of private and public costs of the collection activity, that is, parents are able to push some of the cost of their children's activities onto the local environment. Table 2 shows the reported sources from which wood was collected by rural residents by province and then separates these out, for each geographic area, the sources of collection for the poorest 50 percent of households. Most firewood is collected from households' own land and from "other private" land. Overall in Pakistan, state/forest land and common/village land account for only a quarter of firewood collection. This is higher in NWFP and much higher in remote and sparsely populated Baluchistan.

This prevalence of firewood collection on private land highlights several points. First, only a small fraction of household firewood collection consists of felling trees. While purchased firewood tends to be large branches and stems, collected firewood is more likely to be small twigs, shrubs, leaves and roots (Ouerghi and Heaps, 1993). This composition of the types of firewood and the prevalence of collection of firewood from "own land" reveals the multiple uses of individually owned trees, and trees and shrubs that may be present on the land for other reasons (e.g. erosion control, shade provision, boundary demarcation) have the secondary benefit of providing firewood.

Table 2: Source of collected wood among rural households which collect wood, by province.							
	(1)	(2)	(3)	(4)	(5)	(6)	(3)+(4) + (5)+(6)
	Own Land	Other private land	State / forest land	Waste	Common / village land	Other	Sub-total: non-private
All rural households							
Pakistan	26.0	34.1	12.3	0.5	13.3	13.7	39.8
Punjab	35.8	33.7	7.7	0.8	8.4	13.8	30.7
Sindh	22.7	46.5	17.9	0.4	9.6	13.5	41.4
NWFP	35.9	19.7	15.3	0.0	18.2	10.8	44.3
Baluchistan	3.3	6.6	10.9	0.0	56.0	23.1	90.0
Households in poorest 50 percentile of expenditures per person							
Pakistan	21.2	37.5	12.1	0.5	13.6	15.2	41.4
Punjab	26.6	41.8	7.6	0.9	9.1	14.0	31.6
Sindh	9.8	45.3	18.8	0.4	13.3	12.4	44.9
NWFP	31.9	24.1	14.7	0.0	14.7	14.7	44.1
Baluchistan	2.0	3.9	15.7	0.0	41.2	37.3	94.2
Source: PIHS							

Second, a significant fraction of firewood collected off of "other private land" suggests that, at least in many areas of Pakistan, the value of firewood has not reached the point where exclusion or charges for collection activity, even on private land, are profitable. This brings us back to an issue discussed in the opening section: soil, forests, water, or grazing land are not intrinsically private property (at one extreme) or open access (at the other). The elements of ownership of resources (use, transfer rights and residual claims) depend not only on background social and legal conventions but also on the ratio of the value of the commodity under one regime or another. Even with constant prices for enforcement, as a resource becomes more valuable

there may be an endogenous switch from a regime of open access to more limited access (for example, restricted common property or purely private property).

One important determining factor of this regime change will be population density itself. All else equal, as population density (and the density of economic activity) rises, the value of land rises which increases the likelihood of a switch to private property. As discussed above, however, increasing scarcity of private property natural resources can be expected to have a very different impact on fertility decisions than open access natural resources: the household cannot escape the full natural resource consequences of its fertility decisions[13].

This combination of differential household behavior with respect to common versus private property treatment of natural resources, and the endogeneity of the socially enforced property rights over certain resources will make for interesting dynamic behavior of a fully articulated system. It is possible that at stages of low population density initial increases in population density will lead to greater demand for children. This greater population density will in turn accelerate environmental degradation and raise the scarcity value of the open access resource. As long as the resource remains open access this will (or empirically may) in turn increase the demand for children. After a certain point, the increased population density may change the value of the resource such that it switches from open access to more limited access, such as private property. Once a natural resource is privatized, the negative externality to child bearing disappears and is internalized by the household. From that point on, households would respond to further deterioration in availability by reducing their demand for children (unless children have

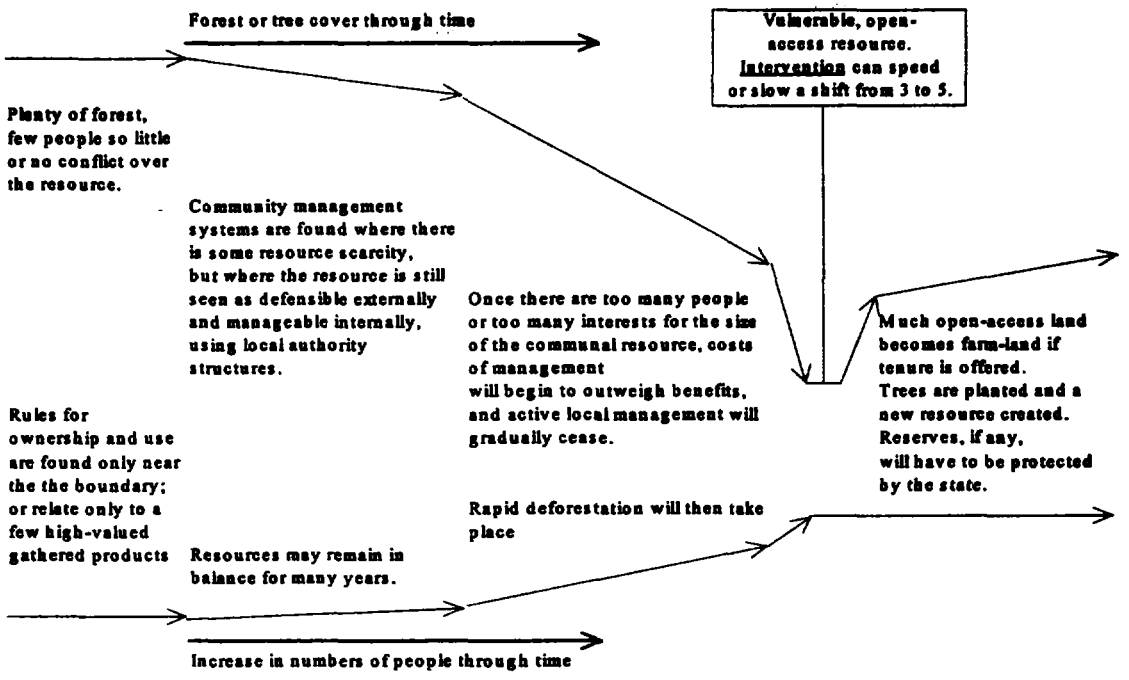
[13] The differing views on the impact of population density on agricultural institutions and practices are well described in Turner, Hayden, and Kates (1993).

a comparative advantage over adults in the market supply from private property which is unlikely).

Recent studies (Ouerghi 1993, Leach 1993) on the market for firewood in Pakistan argue that something very much like the switch to a private property regime may have already occurred or is about to occur in some, and perhaps most, regions of Pakistan. There is now a large market for firewood and most of the new tree plantings are on large plantation style lots. These plantation markets supply firewood indirectly from twigs and branches cut (as the main market for plantation trees is construction poles or other uses). Figure 1 suggests something of the time path of the market for firewood in Pakistan with an ongoing, and perhaps well advanced in many regions, evolution from plentiful open access forest resources to scarce, market provided firewood.

Figure 1

From forest management to tree planting – options dictated by population and external intervention



Source: Chart devised by Gill Shepherd, ODI, autumn 1992/spring 1993, in Ouerghi, 1993

Are children relatively devoted to collection activities? In the PIHS data there are two types of time allocation data. All individuals aged 10 and over were asked about their "labor" time devoted to a variety of tasks, either wage labor or the production of (potentially) marketable commodities. In addition, all females (but only females) aged 10 and over were asked about their participation in thirteen household production tasks.

Table 3: Allocation of time in household activities in hours per week (and by fraction of total time) in selected tasks for women and girls, by urban-rural residence

	Urban Girls	Urban Women	Rural Girls	Rural Women	Age: 10	Age: 25
Fetching water	0.3 (1.9%)	0.4 (1.3%)	1.6 (7.7%)	1.8 (5.1%)	1.5 (11.4%)	2.7 (4.4%)
Firewood collection	0.0 (0.2%)	0.1 (0.2%)	1.2 (5.9%)	1.3 (3.7%)	1.5 (11.2%)	1.4 (2.4%)
Animal care, fodder	0.2 (1.6%)	0.6 (1.9%)	1.9 (9.0%)	3.8 (10.3%)	1.6 (12.1%)	3.9 (8.2%)
Dung cake preparation	0.1 (0.4%)	0.2 (0.6%)	0.5 (2.5%)	1.1 (3.0%)	0.4 (3.3%)	1.1 (2.2%)
Sub-total: Collection tasks	0.6 (4.1%)	1.3 (3.9%)	5.2 (25.1%)	8.1 (22.2%)	5.0 (38.1%)	9.1 (17.2%)
Meals to workers	0.0 (0.0%)	0.0 (0.0%)	0.2 (0.9%)	0.5 (1.4%)	0.2 (1.4%)	0.4 (0.8%)
Grinding flour	0.0 (0.2%)	0.1 (0.2%)	0.1 (0.5%)	0.4 (1.0%)	0.0 (0.2%)	0.6 (0.8%)
Going to market	0.2 (1.3%)	1.0 (3.2%)	0.1 (0.5%)	0.4 (1.1%)	0.1 (0.8%)	0.3 (0.6%)
Stitching	0.6 (4.1%)	1.1 (3.3%)	0.7 (3.6%)	0.9 (2.6%)	0.2 (1.4%)	1.4 (3.0%)
Milk, ghee preparation	0.0 (0.1%)	0.1 (0.4%)	0.2 (1.0%)	1.3 (3.6%)	0.0 (0.2%)	1.0 (2.2%)
Sub total: Other tasks	0.9 (5.6%)	2.3 (7.2%)	1.3 (6.4%)	3.5 (9.7%)	0.5 (4.1%)	3.6 (7.4%)
Cooking	6.9 (45.3%)	14.2 (44.4%)	7.3 (35.1%)	12.3 (33.8%)	2.6 (20.2%)	15.9 (33.6%)
Cleaning	5.9 (38.6%)	8.5 (26.4%)	5.8 (28.1%)	7.4 (20.2%)	3.8 (29.1%)	10.4 (22.0%)
Child care	1.0 (6.3%)	5.8 (18.8%)	1.1 (5.3%)	5.1 (14.1%)	1.1 (8.5%)	9.9 (19.8%)
Total	15.3 (100%)	32.0 (100%)	20.7 (100%)	36.5 (100%)	13.0 (100%)	48.9 (100%)

Notes: Figures in parentheses are percent of time devoted to activity. "Girls" in this table refers to unmarried female household members less than 18 years old.

Source: PIHS

Table 3 shows the allocation of time to each of the thirteen household tasks for women and for girls[14]. On average, women in Pakistan spend 35 hours per week in household activities, while girls spend 18 hours per week on these tasks. The three most time consuming tasks for women are cooking (38 percent), cleaning (23 percent) and child care (16 percent) which together account for 77 percent of time devoted to household tasks.

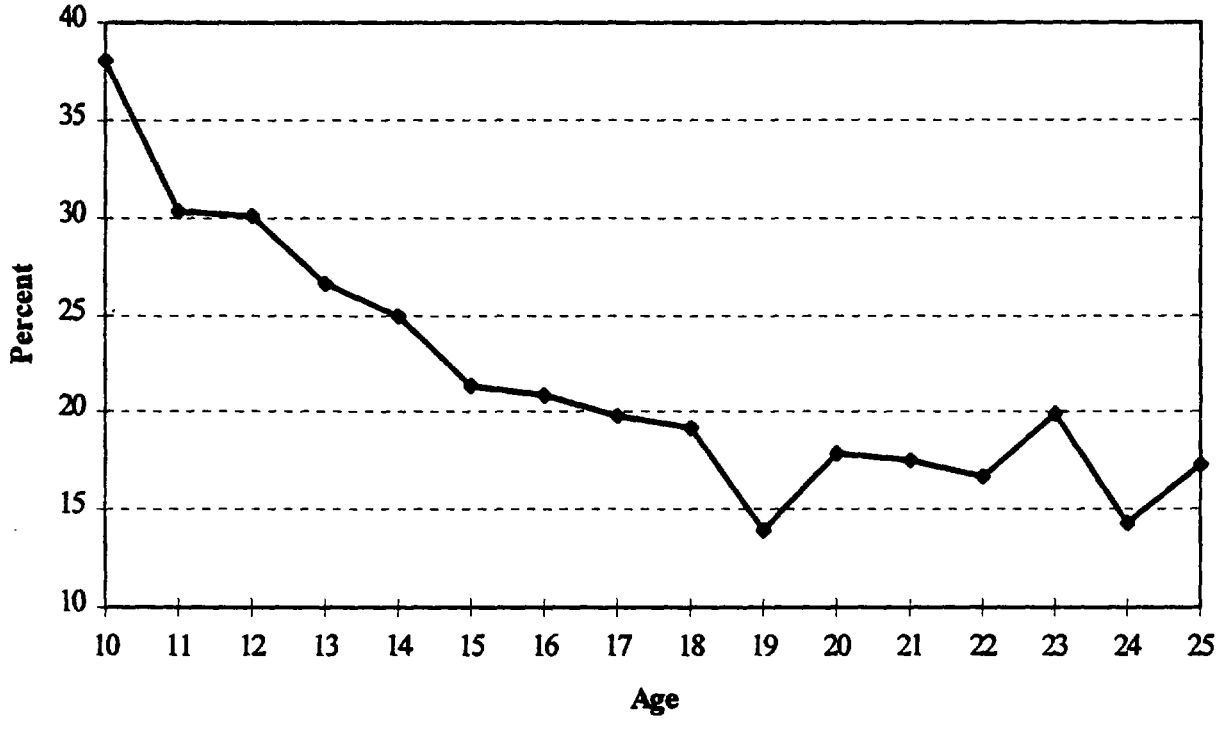
We classify fetching water, collecting firewood, collecting fodder for animals, and dung cake preparation as those "collection" activities which involve natural resources. Collection activities account for 14 percent of time for women on average and 17 percent for girls. Not surprisingly, these activities are much more important both absolutely and as a fraction of time for rural women. Urban women and girls spend only 1.3 and 0.6 hours per week on collection activities, compared to 8.1 hours and 5.2 hours per week for rural women and girls. Rural women work 4 hours more per week on household tasks, hence the difference in collection activities is by itself greater than the total amount of labor time difference.

What types of work do children do? As suggested as part of the vicious circle hypotheses, the percentage of time allocated to collection activities is much higher at young ages. The final two columns of table 3 time allocation of rural females at ages 10 and 25. Whereas 10 year olds devote 38 percent of their time to collection activities which falls to 17 percent by age 25. Figure 2 shows the steady decline in this percentage of time in collection activities by age.

[14] In this discussion, "girls" refers to unmarried females less than 18 years old.

Figure 2

Share of time in household activities devoted to "collection activities"
Rural females aged 10 to 25



This relatively high fraction of child time devoted to collection activities is consistent with a number of studies of time allocation. Table 4 shows the results of four other studies of time allocation in Asian countries for both the total time devoted to household activities and the fraction of that time devoted to collection activity (appendix 2 reports more detail of these other studies).

Table 4: Allocation of time by children to collection activities from other studies				
Country	Total time to HH activities (hours per week)		Fraction of time to collection activities (percent)	
	Woman	Child	Woman	Child
This study: Average	36.5	20.7	22.2	25.1
This Study: 75th percentile	52.5	29.5	34.5	41.9
Pakistan (Alderman and Chishti)	32.0		16.4	
Javanese village	32.8	20.9 (F)	3.5	22.9 (F)
Nepalese village (A)	44.3	33.1 (F)	36.1	56.3 (F)
Nepalese villages (B)	45.6	20.5 (all)	26.5	68 (all)
Nepalese villages (C)	56.0	13.5 (all)	38.9	68.6 (all)

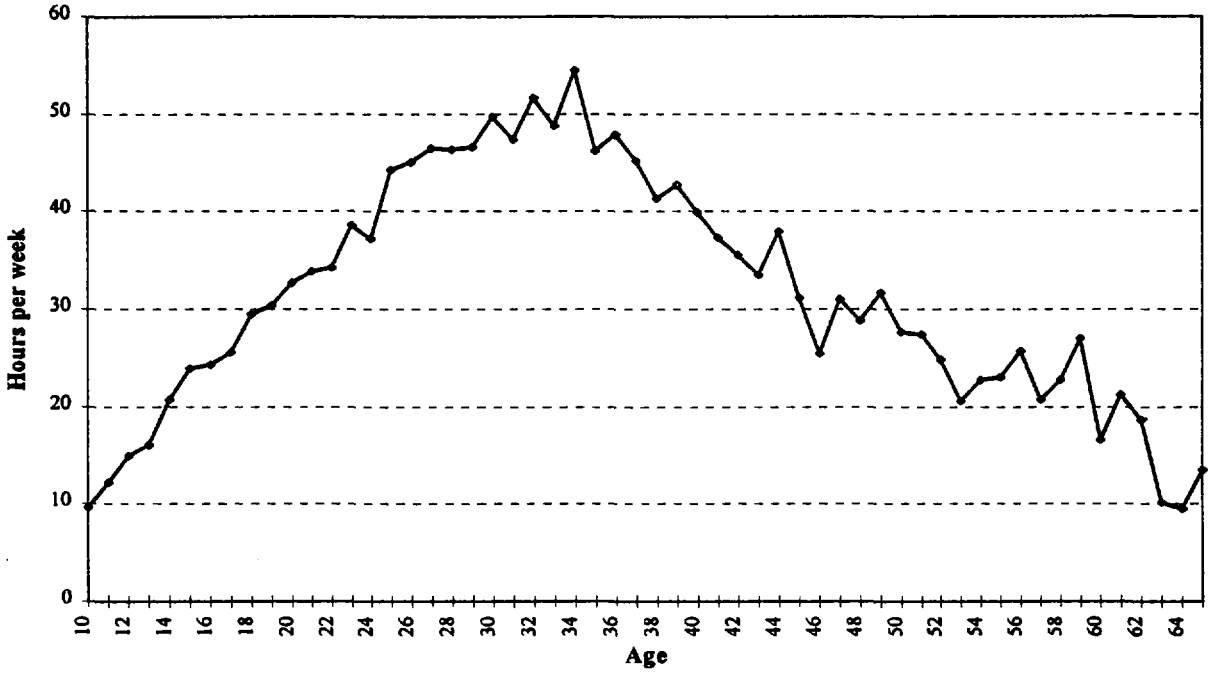
Source and notes: Pakistan, based on Alderman and Chishti (1991) table 2 based on time allocation for all rural females over 10, with same classification of collection activities as our study. Javanese village and Nepalese village (A) are based on Nag, White and Peet (1980) table 10.2 and 10.4, based on female time use. Children are ages 6 to 14. Collection activities are firewood collection and animal care. Nepalese Villages (B) is based on Acharya and Bennett (1981) based on five hill and one tarai village, children are 6 to 15, collection activities are fuelwood collection, water collection, leaf fodder collection. Nepalese villages (C) is based on Kumar and Hotchkiss (1988) based on three hill districts, children are 6-15, collection activities are collection of fuelwood, water, grass, and leaf fodder and the assumption that half of grazing is done by children. Nepalese B and C are based on time use of male and female children. Time use per week based on six day work week.

Does the presence of children alter adult's time use? Although the *share* of time devoted to collection activities is decreasing with age, we now turn to how much *total* time is spent on collection activities by children. How important is collection done by children as a fraction of total household time spent on various household tasks? Table 3 showed that the share of time devoted to collection activities falls from 38 percent to 17 percent between the ages of 10 and 25. Figure 3 shows the hours of work in household tasks per week by age for females from age 10 (the lowest age with this information in the survey) to age 65. This rises sharply from 10 hours per week at age ten to 24 hours per week by age fifteen, to 44 hours per week by age twenty-five. Total time devoted to household activities rises sufficiently with age that the absolute amount of

time in collection activities rises substantially, from 5.0 hours for a ten year old to 9.1 hours for a women aged 25.

Figure 3

Hours per week spent by females in household activities, by age



In table 5 we shift from the individual level, how much work each person does, to the household level. How much total time is spent by all members of the household, what is its allocation across tasks, and how much of each task is done by children? The total female time per household in household tasks in rural areas is 78 hours a week. Since from figure 3 the average time per woman peaks at around 50 hours per week (at ages 30 to 35) it is obvious that major time contributions are made by other household members. Of the total time devoted to household tasks in rural areas, 18 hours a week, or 2.5 hours per day per household, are devoted

to collection activities, although this total varies substantially within Pakistan. Only about 17 percent of female time devoted to household tasks is contributed by children.

Table 5: Total female time devoted to household tasks in Pakistan in rural areas, by type of activity, and the fraction which is done by (female) children.

	Total female household hours devoted to task	Share of total time devoted to task	Fraction of time in task which is performed by children
Fetching water	4.4	5.6%	20.3%
Firewood Collection	3.2	4.1%	19.5%
Animal care, fodder	7.9	10.1%	13.7%
Dung Cake Preparation	2.3	2.9%	13.9%
Sub-total, collection	17.8	22.8%	
Meals to Workers	1	1.3%	13.4%
Grinding Flour	0.7	0.9%	10.9%
Going to Market	0.8	1.0%	7.5%
Stitching	2.2	2.8%	20.3%
Milk, Ghee preparation	2.4	3.1%	5.2%
Sub-total, other	7.1	9.1%	
Cooking	26.6	34.1%	17.2%
Cleaning	16.9	21.6%	21.6%
Child Care	9.7	12.4%	7.1%
Total	78.1	100.0%	16.6%
N	2254	2254	2254

Note: Fraction of time in task which is performed by children is only for households in which the task is performed.

Source: PIHS

Some activities, particularly fetching water (20.3 percent), collecting firewood (19.5 percent), and cleaning (21.6 percent) appear to be "child" tasks. Others, such as animal fodder collection, are proportionately less performed by female children. Perhaps surprisingly, given other work which suggests a large degree of substitutability of mother's and older daughters' time

in caring for young children, child care appears not to be a child activity. Children do contribute a significant fraction of all hours spent in household tasks. The impact of this on mother's time and total hours by age is examined below.

Bringing the various pieces of information together, we find that table 1 reports that roughly 60 percent of the time devoted to firewood collection comes from women and children, while table 5 suggests that only 20 percent of female time to firewood collection comes from children. The composition of members of trips to collect firewood in table 6 suggests that children account for about 15 percent of the people who go to collect firewood. Depending on the region, there are nearly equal numbers of adult males and females. The number of children varies from only 9 percent in Punjab and Baluchistan to 25 percent for the poorer households in Sindh and NWFP. Together the evidence suggests that an important, but not overwhelming part of all firewood collection is done by children.

Table 6: Composition of most recent trip for wood collection, in rural areas among households that use firewood					
	Number of people	Percent which were:			
		Adult Males	Adult Females	Children (male and female)	Servants and others
All Pakistan	2.24	47.41	34.85	14.23	3.51
Punjab	2.16	50.54	37.09	9.83	2.54
Sindh	2.31	42.76	33.18	20.54	3.52
NWFP	2.33	49.63	28.34	16.50	5.53
Baluchistan	2.13	43.89	41.54	8.69	5.88
Poorest 50th household per person expenditure percentile					
All Pakistan	2.23	44.38	37.60	16.57	1.45
Punjab	2.26	47.03	40.36	12.01	0.60
Sindh	2.22	36.26	36.33	25.16	2.25
NWFP	2.35	45.26	32.55	17.97	4.22
Baluchistan	2.29	52.65	37.76	8.49	1.10
Source: PIHS					

Do rural families alter their firewood use and collection activities in response to the presence of children? Table 7 presents the association of household composition and the number of hours devoted by mothers to various tasks.[15] The fact that time use cannot be negative implies the impact of children has a particular non-linear structure, that is, time in each task could be higher or lower either because it equaled zero and now positive or because it was positive and

[15] It should perhaps be emphasized here that these estimates--and those subsequent equations of the relationship between household composition and time devoted to tasks--do not correspond to the experiment of exogenously adding an individual of a particular age to the household. Such an interpretation is inconsistent with the endogenous demand for children (taken up in subsequent sections) being determined by their value from carrying out household tasks.

now has changed.[16] Because these estimates are a combination of changes at the limit (from zero to positive hours), and changes above the limit, the proportion of the average total change due to the response above the limit is also reported in the table (as derived in McDonald and Moffitt, 1980).

These results indicate that the presence of children under 10 is associated with increases in a rural mother's time in household activities, whereas each child over ten is associated with less time in household activities. The point estimates from table 7 indicate that by age 16 a female child has a been a net contributor to hours in household activities, with the positive contributions of labor from 10 to 15 offsetting the additions to mother's time from years 0 to 10.[17]

Table 7 also presents estimates of the relationship between household composition variables and total time devoted female time to each of several activities. These results suggest that an additional child in the household between 10 and 15 is associated with an additional 5 hours per week devoted to all household activities by all members of the household. But females 10 to 15 years old devote on average 17 hours to household activities. The net contribution to the household is 12 hours on average. Mother's time is reduced only 2.6 hours. This difference is

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[16] Tobit estimation is used because a significant number of women devote zero hours to some of the tasks (i.e. the dependent variable is censored at zero). If the underlying (non-censored) model is $H^* = X\beta + \varepsilon$, then the change in observed (censored) H due to a change in one of the Xs, $\delta H / \delta X_i$, is equal to $\beta_i F(z)$, where β_i is the Tobit parameter estimate, F() is the standard normal cumulative distribution function, and z is equal to $X\beta/\sigma$ where σ is the standard deviation of ε. McDonald and Moffitt (1980) recommend evaluating this at the mean of the Xs. These are the average derivatives implied by tobit estimation of the relationship between mothers time devoted to various household tasks and household composition in rural areas

[17] With discounting, this does not necessarily make a child a positive payoff, even in strictly time terms. Assuming a discount rate of 3 percent, (which is low for rural households in Pakistan) a female child staying until age 18 would pay off in mother's time terms.

Table 7: Mean change in expected hours per week per woman in household activities, rural areas

	Mothers				Sum for all household females over 10 years old			
Dependent variable in hours per week	Total	Child care	Cooking and cleaning	Collec-tion activities	Total	Child care	Cooking and cleaning	Collection activities
Household composition variables: Number of household members								
above 15	-3.219 (<0.001)*	-0.701 (<0.001)*	-2.103 (<0.001)*	-0.412 (0.001)*	5.973 (<0.001)*	-0.037 (0.731)	2.738 (<0.001)*	1.139 (<0.001)*
between 10 and 15	-2.611 (<0.001)*	-0.392 (0.023)*	-1.652 (<0.001)*	-0.463 (0.059)	5.249 (<0.001)*	-0.325 (0.161)	4.165 (<0.001)*	0.912 (0.020)*
between 5 and 10	0.974 (0.038)*	0.646 (<0.001)*	0.147 (0.635)	0.122 (0.533)	5.146 (<0.001)*	1.325 (<0.001)*	1.707 (<0.001)*	1.432 (<0.001)*
between 2 and 5	2.153 (0.001)*	1.309 (<0.001)*	0.577 (0.181)	0.277 (0.306)	5.987 (<0.001)*	3.080 (<0.001)*	1.875 (<0.001)*	0.567 (0.203)
under 2	1.001 (0.179)	1.788 (<0.001)*	-0.504 (0.311)	-0.271 (0.390)	7.490 (<0.001)*	5.031 (<0.001)*	1.987 (0.003)*	0.437 (0.409)
Other variables:								
HH expenditure per person (natural log)	3.640 (<0.001)*	-0.606 (0.030)*	3.586 (<0.001)*	-0.266 (0.495)	3.321 (0.019)*	-1.040 (0.009)*	4.699 (<0.001)*	-1.663 (0.011)*
Age	0.635 (0.020)*	0.193 (0.042)*	0.161 (0.374)	0.454 (<0.001)*				
Age squared	-0.016 (<0.001)*	-0.005 (<0.001)*	-0.007 (<0.001)*	-0.006 (<0.001)*				
Female head	1.890 (0.639)	0.300 (0.800)	3.586 (0.175)	-0.430 (0.800)				
Spouse present	6.504 (0.636)	-0.318 (0.948)	4.386 (0.641)	1.475 (0.788)				
Constant	23.843 (0.127)	4.567 (0.397)	8.779 (0.409)	-0.583 (0.926)	13.040 (0.145)	1.877 (0.450)	-5.083 (0.334)	13.188 (0.001)*
Summary statistics:								
Share of change due to the response above zero	81.2%	36.4%	69.1%	48.9%	89.2%	43.3%	86.6%	52.6%
Mean hours	42.6	6.1	22.8	9.7	78.5	9.7	43.5	17.6
N	2101	2101	2101	2101	2254	2254	2254	2254

Notes: P-values of tobit parameter estimates are reported in parenthesis, (*) indicates significantly different from zero at the 95% level

Source: PIHS

accounted by two factors. First, child labor is not likely to be as productive and so will not reduce adult's time one for one. Second other females in the household will also reduce their time.

Children and collection activities. The general information on time use does not reveal whether children actually alter the decisions of the household about the relative value of collection activities. In the PIHS data, however, we can examine whether rural households with children of various ages are more or less likely to collect versus purchase firewood. Table 8 shows the estimated effect of a change in a variable on the (1) probability of collecting only (versus collection and purchase or purchase only) and the probability of collecting only or collecting and purchasing (versus purchase only) and (2) the expected quantity of firewood consumed.[18] The patterns found here are somewhat puzzling. Each additional non-child in the household is associated with an increase in the probability of collection only, whereas each child aged 11 to 15 is associated with a decrease in this probability, each child aged 5 to 10 is associated with an increase in this probability (insignificantly), while a very young child (under 5) is associated with a decrease in this probability. If children from 5 to 15 were an important asset to the household in their ability to collect firewood, one might expect that the probability of collection only would increase with their presence. It appears that while a large household *per se* is more likely to only collect, the presence of children does not increase the likelihood of collection.

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[18] If the underlying continuous model for collect only is $C^*=X\beta+\varepsilon$, then the change in observed (binary 0/1) C due to a change in one of the Xs, $\delta C/\delta X_i$, is equal to $\beta_i f(z)$, where β_i is the probit parameter estimate, f() is the standard normal probability density function, and z is equal to $X\beta$. In the reported results, $X\beta$ is evaluated at the means of the Xs. See footnote 16 for the derivation of the firewood quantity estimates.

Table 8: Mean change in probability of firewood collection and, mean change in expected quantity of firewood used, rural households.

Dependent variable:	Collect only (0/1)	Collect only or collect and purchase (0/1)	Consumption of firewood (kg per person)
HH expenditures per person (natural log)	-0.055 (0.003)*	-0.027 (0.117)	1.932 (<0.001)*
Household size			-0.101 (<0.001)*
Household size squared			0.002 (<0.001)*
Number of household members over 15	0.011 (0.032)*	0.010 (0.035)*	
Number of household members 10 to 15	-0.027 (0.013)*	-0.014 (0.179)	0.003 (0.882)
Number of household members 5 to 10	0.009 (0.318)	0.005 (0.586)	-0.014 (0.362)
Number of household members under 5	-0.025 (0.002)*	-0.020 (0.008)*	-0.009 (0.557)
Sindh (†)	0.223 (<0.001)*	0.183 (<0.001)*	0.422 (<0.001)*
Baluchistan (†)	0.161 (<0.001)*	0.132 (0.001)*	0.883 (<0.001)*
NWFP (†)	0.054 (0.078)	0.061 (0.032)*	0.362 (<0.001)*
Summary statistics			
N	2394	2394	2394
Mean of dependent variable	0.577	0.674	0.985
Share of change due to the response above zero			65.3%

Notes: (†) indicates variables for which parameter estimates reported in collect only model are for change in the variable from 0 to 1. P-values of probit or tobit parameter estimates are reported in parenthesis, (*) indicates significantly different from zero at the 95% level.

Source: PIHS

Similar results hold for the total use of firewood. If the presence of children lowered the effective cost of firewood to the household, one might expect to see that households with a greater

child concentration would consume relatively more firewood than more adult intensive households. The results in the third column of table 8 show that while additional household members are associated with lower per person consumption of firewood (perhaps because of economy of scale effects) children do not appear to affect the consumption decision differently than adults.

III) Firewood and fertility

This section estimates directly the association between fertility and firewood scarcity; this is done in two steps. The first step is to identify reasonable proxies for firewood scarcity. In the second step, these proxies are introduced into a reduced form fertility regression.

A) Measures of firewood scarcity

At this stage of the research the only proxies for environmental scarcity or degradation used are those related to firewood and its availability. Given the prominence of deforestation in discussions of the environmental consequences of population this is a useful first pass. The PIHS data have several measures of the scarcity of firewood, some at the household level and some at the cluster sampling unit level.[19]

Households were asked three questions relating to firewood use: first, whether there was a problem with supply; second, the average time devoted to collect firewood; and third, the average distance to the place where firewood was collected. The answers to these household level questions are averaged over all observations in each cluster to obtain cluster specific means. At

[19] The cluster sampling unit is the smallest unit of the census.

the level of the cluster, price data on firewood and dung cakes were also collected directly from a single respondent.

Table 9 reports the averages of these cluster level variables. The proportion reporting having problems because of shortage of firewood supply is only 8 percent. This could be because the question went beyond the ability to collect firewood and included market availability: if the firewood market is effective then local environmental scarcity will not be reflected in an absence of local supply on the market.

Table 9: Summary statistics on cluster level measures of firewood scarcity.

Variable:	Mean	Standard Deviation	Minimum	Maximum	Number of women
Price wood in the market (or mandi) rs/kg	0.93	0.25	0.13	1.74	2223
Problems obtaining wood because of supply (cluster mean)	0.08	0.12	0.00	0.75	3157
Hours for two way trip time to collect wood (cluster mean)	1.91	1.02	0.50	6.33	3157
Kilometers to source of wood, round trip (cluster mean)	2.91	3.53	0.00	21.50	3038
Price of dung cakes (rs/100 cakes)	11.44	5.02	3.00	25.00	483
Density of cluster (acres per HH)	6.72	9.69	0.06	53.46	2869

Source: PIHS

The average time of a two way trip to collect firewood is almost two hours, ranging from a minimum of half an hour to a maximum of over 6 hours per trip. Kilometers to collect wood, average almost 3 km, and vary from 0 km to 21.5 km[20]. The price of firewood varies

[20] Reassuringly if one regresses the minutes per two way trip on the kilometers to source one finds a reasonable relationship, i.e. that each kilometer adds about 23 minutes to the trip.

considerably (the average price is almost 1 rupee per kg and varies from 0.13 to 1.74) although not as much proportionately as the distances or times across clusters[21].

The correlations among the various cluster level measures of firewood scarcity are reported in table 10. The pattern of correlations is reasonable. The price of wood is positively associated with the two-way collection trip time and the price of dung cakes, a close substitute, but the correlation between the price of wood and kilometers to the source of wood is not significantly different from zero. Higher prices are associated with less reported problems with supply, which again may indicate that at a higher price the market provides a supply of wood to areas with little local supply.

Table 10: Correlations amongst various cluster level measures of firewood scarcity, rural women

	Price of wood	Problems with supply (mean)	Hours for two way trip (mean)	Kilometers to source (mean)	Price of dung cakes	Density of cluster
Price of wood	1 (2223)					
Problems with supply (mean)	-0.1852* (2223)	1 (3157)				
Hours for two way trip (mean)	0.2204* (2049)	-0.0669* (2748)	1 (2748)			
Kilometers to source (mean)	-0.0055 (2778)	0.1627* (3038)	0.5336* (2748)	1 (3038)		
Price of dung cakes	0.4603* (467)	0.3761* (483)	0.0807* (400)	-0.1608* (422)	1 (483)	
Density of cluster	-0.0345 (2027)	-0.0959* (2869)	0.0809* (2477)	-0.0086 (2753)	0.0058 (456)	1 (2869)

Notes: (*) indicates that the correlation coefficient is significantly different from zero at the 95% level. The number of observations included in each pairwise correlation is in parenthesis.

Source: PIHS

[21] This is partly because the cluster data on prices were collected from a single source while the cluster averages depend on the variability of the households surveyed.

B) Children ever born, birth in the past five years and firewood scarcity

The regression results presented in table 11 and 12 explore the partial correlation of fertility with firewood scarcity. The various firewood scarcity variables are added to basic reduced form regressions for birth in the past five years and children ever born of ever married women (results for the basic specification, are reported in table A4.1).

The most robust finding in table 11 is that households living in clusters with higher prices of firewood have fewer children, and have a lower probability of having had a child in the past five years. This result holds true when various proxies for the "remoteness" of the cluster are added (such as distance to main market, or district capital, or railroad) to capture the possibility that high prices are simply due to transport costs. It is also robust if the other measures of cluster firewood scarcity are added, either individually or simultaneously. Moreover, the negative impact of the price of wood remains, but it is not always significantly different from zero, when various combinations of other prices are included in the regressions.[22] Although an increase in the price of firewood was thought to reduce the relative price of children by increasing their marginal value product relative to adult wages this finding highlights the difficulties in interpreting reduced form regressions, as without a fully specified model of household behavior one cannot identify the causal mechanism behind any particular partial correlation.

In general, the probability of birth in the past five years is more responsive to measures of scarcity than cumulative children ever born. For example, in the probit regressions for a birth

[22] When the prices of fuel-goods (kerosene and diesel) are included in the CEB [B5Y] equation the p-value is 0.253 [0.001], when the prices of food-goods (basmati rice, low quality rice, chana, sugar, and onions) are included the p-value is 0.009 [0.081], with the prices of other food-goods and other non-food goods (soap and cigarettes) the p-value is 0.129 [0.374], when all of these are included the p-value is 0.613 [0.348]. In these specifications the estimate of the coefficient varies from -0.74 [-0.17] to -0.23 [-0.05].

in the past five years, four of the five cluster level variables are significantly different from zero. Again, the price of wood is strongly negatively associated with a birth. However, other household and cluster variables are consistent with a vicious circle interpretation. Households with greater problems with wood supply (either as measured by a household or a cluster level variable), or households who live in clusters that are further away from a wood source, have a higher probability of having had a birth in the past 5 years.

The vicious circle hypothesis rests on the notion that the costs of environmental degradation are not borne by the household, i.e. that the land from which firewood is gathered under open access like conditions. As mentioned earlier, ownership rights are likely to be the result of an endogenous process and will most likely vary from location to location (see figure 1). In the case under study, we can distinguish across regions within Pakistan. Table 12 reports the same regressions as table 11 region by region.

For most of the results, the findings in the regionally disaggregated analysis are just consistent with those in the national sample. However, the results for the Sindh region are strongly consistent with the vicious circle hypothesis. Except for two (the price of wood which is significantly negatively related to the probability of birth, and density of cluster which is insignificantly positively related to the probability of birth), all the scarcity measures have the expected sign and of these eight, six are significantly different from zero. Using the stages described in figure 1 this would suggest that the Sindh region was in stage 1 or stage 2, i.e. a region in which forest land is relatively abundant. In their description of usage patterns, Ouerghi and Heaps (1993, p. 4-9) claim that high firewood use in the Sindh region is consistent with the abundance of firewood rich land (i.e. riverain forests) relative to other regions, as well as a

relative lack of alternative fuels. They also claim that although the NWFP region has the largest forest cover, demand for firewood may be higher due to its rigorous winter. This higher demand could hasten the move from stage 2 to stages 3 and 4 in figure 1, i.e. contribute to a change in ownership rights and hence we would not observe the vicious circle.

A claim that these results confirm the existence of a vicious circle between environmental degradation and the demand for children is clearly far too strong. The results, however, are supportive of the notion that there is a stage in the relationship between environmental degradation, fertility, and land ownership rights in which children are in relatively high demand[23].

[23] These supportive, but tentative, empirical results are consistent with Cleaver and Schreiber (1994) who find that the rate of deforestation is positively related to the total fertility rate in a pure cross section of thirty eight African countries, but that the estimated deforestation effect on fertility was small and insignificant in a pooled time series cross-section estimation when cultivable land area was also included.

Table 11: Estimates of the change in the probability of a birth in response to a change in a measure of firewood scarcity in probit regressions of a Birth in the Past 5 Years on the sample of, for rural, ever married women, age 19 and over and the coefficients on measures of firewood scarcity when entered singly into OLS regressions of Children Ever Born for rural ever-married women 14 and over.

		Birth in the Past 5 Years (0/1)		Children Ever Born	
Variable added		All rural Pakistan	Poorest 50th Expenditure per Adult Percentile	All rural Pakistan	Poorest 50th Expenditure per Adult Percentile
1	Mean problems with supply (cluster level)	0.319 (<0.001)* 2908	0.203 (0.017)* 16311	0.621 (0.123) 3184	0.715 (0.165) 1735
2	Mean kilometers to source (cluster level)	0.011 (<0.001)* 2908	0.011 (<0.001)* 1587	0.021 (0.122) 3062	-0.001 (0.963) 1691
3	Mean hours for two way trip (cluster level)	-0.021 (0.033)* 2633	-0.007 (0.572) 1426	-0.058 (0.321) 2773	-0.118 (0.193) 1520
4	Density of cluster (cluster level)	0.001 (0.280) 2750	0.002 (0.047)* 1491	-0.006 (0.219) 2892	-0.003 (0.731) 1589
5	Price of wood (cluster level)	-0.229 (<0.001)* 2139	-0.175 (0.002)* 1112	-0.609 (0.017)* 2234	-0.017 (0.963) 1176
6	Problems with wood supply (†) (household level)	0.120 (0.001)* 3030	0.100 (0.016)* 1631	0.093 (0.593) 3184	0.158 (0.503) 1735
7	Hours for two way trip (mean) (household level)	-0.015 (0.054) 1624	-0.016 (0.089) 899	-0.012 (0.781) 1716	-0.043 (0.511) 964
8	Kilometers to wood source (household level)	0.001 (0.882) 1695	0.003 (0.396) 937	0.017 (0.430) 1792	-0.020 (0.498) 964

Notes: (†) indicates variables for which parameter estimates reported in birth in the past 5 years model are for change in the variable from 0 to 1. (*) indicates significant at the 95% level.

Source: PIHS

Table 12: Regionally disaggregated estimates of the change in the probability of a birth in response to a change in a measure of firewood scarcity in probit regressions of a Birth in the Past 5 Years on the sample of, for rural, ever married women, age 19 and over and the coefficients on measures of firewood scarcity when entered singly into OLS regressions of Children Ever Born for rural ever-married women 14 and over.

		Birth in the Past 5 Years				Children Ever Born			
Variable added		Punjab region	Sindh region	NWFP region	Baluchistan region	Punjab region	Sindh region	NWFP region	Baluchistan region
1	Mean problems with supply[a]	0.023 (0.781) 1477	1.100 (<0.001)* 846	-1.678 (0.186) 488	0.159 (0.576) 219	0.629 (0.172) 1542	0.017 (0.987) 888	5.257 (0.273) 527	1.474 (0.333) 227
2	Mean kilometers to source[a]	-0.001 (0.815) 1407	0.012 (<0.001)* 843	0.023 (0.002)* 460	-0.0005 (0.976) 198	-0.031 (0.243) 1472	0.037 (0.112) 885	0.031 (0.176) 499	0.139 (0.124) 206
3	Mean hours for two way trip[a]	-0.090 (0.001)* 1281	0.075 (<0.001)* 755	0.032 (0.209) 424	-0.057 (0.029)* 173	-0.217 (0.021)* 1338	-0.024 (0.885) 797	0.021 (0.831) 458	0.067 (0.631) 180
4	Density of cluster[a]	-0.005 (0.001)* 1436	0.003 (0.141) 607	0.003 (0.070) 488	0.008 (0.074) 219	-0.012 (0.173) 1499	-0.015 (0.470) 639	-0.005 (0.518) 527	0.017 (0.478) 227
5	Price of wood[a]	-0.139 (0.013)* 1072	-0.359 (<0.001)* 671	-0.017 (0.923) 293	-0.217 (0.112) 103	-0.147 (0.661) 1116	-0.256 (0.690) 700	-1.301 (0.035)* 309	-2.237 (0.001)* 109
6	Problems with wood supply[b] (†)	0.076 (0.106) 1477	0.148 (0.001)* 846	0.206 (0.444) 488	0.130 (0.317) 219	0.439 (0.064) 1542	-0.152 (0.619) 888	-0.094 (0.915) 527	-0.674 (0.311) 227
7	Hours for two way trip[a] (mean)	-0.043 (0.001)* 727	0.017 (0.251) 506	-0.016 (0.362) 283	-0.042 (0.156) 108	-0.152 (0.046)* 762	0.179 (0.068) 535	-0.068 (0.330) 306	0.096 (0.526) 113
8	Kilometers to wood source[a]	-0.005 (0.344) 764	0.007 (0.177) 533	0.002 (0.880) 287	-0.013 (0.357) 111	-0.059 (0.084) 801	0.124 (<0.001)* 565	-0.137 (0.008)* 310	0.026 (0.746) 116

Notes: (†) indicates variables for which parameter estimates reported in birth in the past 5 years model are for change in the variable from 0 to 1. (*) indicates significant at the 95% level. (a) Cluster level variable. (b) Household level variable.

Source: PIHS

Conclusion

This paper establishes several facts related to a vicious circle between environmental degradation and fertility:

- Firewood is an important part of the consumption bundle of rural households.
- In many rural regions firewood is often collected from open access or common or quasi-common property. Poorer households are more likely to collect rather than purchase firewood.
- Children (at least the female children for which we have data) are relatively specialized in collection activities, especially at young ages.

These facts enhance the plausibility of the general story that environmental scarcity could possibly raise demand for children.

There are several findings however that may be inconsistent with a vicious cycle story:

* patterns of collecting versus purchasing firewood do not correspond in an obvious way to demographic structure -- households with more under 5 year olds and with more 11 to 15 year olds are significantly less likely to collect only, and those with more over 15 year olds are more likely to collect only or to combine collecting and purchasing;

* while children's time allocation is relatively collection activity intensive, it is not noticeably more so over the entire "child" period (say 9 to 18 years old) than women's time, and women's time is also devoted to child rearing. A rise in the relative value of collection activities would also therefore raise the price of time devoted to child activities;

* adding the available set of (admittedly very crude) proxies for the scarcity of firewood to a simple regression does not yield results which are strikingly consistent with the

vicious circle hypothesis, although it does support the notion that in some regions the hypothesis may hold.

This leads to three observations. First, there are a number of reasons to expect that we would not be able to capture the impact of firewood scarcity on fertility in our data. We do not have *time series* data on the scarcity in various regions and the scarcities may have changed dramatically and differentially over the years. Therefore, we cannot relate the conditions on firewood at the time to the fertility conditions at the time. In addition, the magnitude of the *effect* itself is likely to be small. Even if firewood is a substantial fraction of the budget and even if children are quite collection activity intensive, it is still the case that the change in the perceived relative cost of children due to environmental changes is likely to be small. Searching for a smallish effect with very noisy measures is likely to end in frustration.

Second, the failure to identify a large feedback effect from degradation to fertility is no cause for complacency. Even models with zero feedback or weak negative feedback could produce unstable environmental conditions. Anything that reduces such mitigating factors increases the likelihood of bad outcomes.

Third, a vicious circle between environmental degradation and the demand for children will only exist in certain conditions which may change in part as an endogenous response to population pressures (which are implied by increases in fertility). If the change is such that households bear the costs of the environmental degradation directly (i.e. a switch from common to private property regimes), then this will shift the effect on the demand for children. The

vicious circle will be as much the product of social and institutional arrangements as an intrinsic phenomenon.

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Appendix 1: Fuel and firewood use in Pakistan

Table A1.1: Fraction of households using firewood, by urban-rural residence and province.				
	Rural	N	Urban	N
All Pakistan	90.5	2388	47.3	2385
Punjab	86.3	1241	50.3	1203
Sindh	93.1	667	26.7	654
NWFP	97.6	336	65.5	336
Baluchistan	97.9	144	66.6	192
Source: PIHS				

Table A1.2: Household energy demand, by activity and type of fuel (in TOE)							
Activity:	Cooking	Space Heating	Water Heating	Lighting	Space cooling	Other	Total
Fuel:							
Woodfuels	8623 (80.2%) [55.0%]	863 (8.0%) [75.2%]	1064 (9.9%) [71.4%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	206 (1.9%) [31.1%]	10756 (100%) [53.8%]
Dung	3429 (94.9%) [21.9%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	184 (5.1%) [27.8%]	3613 (100%) [18.1%]
Crop residues	2281 (81.0%) [14.5%]	225 (8.0%) [19.6%]	282 (10.0%) [18.9%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	28 (1.0%) [4.2%]	2816 (100%) [14.1%]
Natural gas	1212 (85.7%) [7.7%]	59 (4.2%) [5.1%]	144 (10.2%) [9.7%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	1415 (100%) [7.1%]
Electricity	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	304 (35.7%) [44.6%]	319 (37.5%) [100%]	228 (26.8%) [34.4%]	851 (100%) [4.3%]
LPG	90 (97.8%) [0.6%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	2 (2.2%) [0.3%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	92 (100%) [0.5%]
Kerosene	49 (11.1%) [0.3%]	0 (0.0%) [0.0%]	0 (0.0%) [0.0%]	376 (85.1%) [55.1%]	0 (0.0%) [0.0%]	17 (3.8%) [2.6%]	442 (100%) [2.2%]
Total	1586 (78.5%) [100%]	1147 (5.7%) [100%]	1490 (7.5%) [100%]	682 (3.4%) [100%]	319 (1.6%) [100%]	663 (3.3%) [100%]	19985 (100%) [100%]
Note: Figures in parenthesis are percent by activity, figures in brackets are percent by fuel							
Source: Ouerghi and Heaps (1993)							

Table A1.3: Total, modern, and biofuel use by urban-rural residence in Pakistan (in TOE)			
	Urban	Rural	All Pakistan
Firewood	1708	8926	10634
Dung	511	3103	3614
Crop Residues	286	2529	2815
Charcoal	17	102	119
Sub-total biofuels (Percent)	2522 (56%)	14660 (95%)	17182 (86.2%)
Sub-total modern fuels (Percent)	1980 (44%)	765 (5%)	2745 (13.8%)
Total	4502	15425	19927
Source: Ouerghi and Heaps (1993)			

Table A1.4: Mean and median firewood use per day per household in Pakistan, in households using firewood, by urban-rural residence and province.						
	Rural			Urban		
	Mean	Median	N	Mean	Median	N
All Pakistan	7.4	6.0	2100	5.8	5.0	1051
Punjab	6.0	5.0	1022	5.2	4.9	553
Sindh	7.8	7.1	619	5.1	5.0	174
NWFP	9.1	6.4	321	5.7	4.5	203
Baluchistan	12.3	10.0	138	9.3	10.0	121
Source: Author's calculations based on the PIHS						

Table A1.5: Among households that use firewood, fraction that collect, purchase or both			
	Purchase only	Purchase and Collect	Collect only
All Pakistan			
Urban	79.9	4.3	15.9
Rural	24.9	10.9	64.2
Rural only, regional disaggregations			
Punjab region	27.7	12.7	59.6
Sindh region	16.4	7.5	76.2
NWFP region	32.5	12.8	54.7
Baluchistan region	23.4	8.5	68.1
Rural only, poorest 50th household expenditure per person percentile in each geographic location			
Rural, all Pakistan	23.6	9.6	66.9
Punjab region	29.6	11.2	59.2
Sindh region	13.6	4.7	81.7
NWFP region	26.5	14.5	59.0
Baluchistan region	16.9	9.9	73.2
Source: PIHS			

Appendix 2: Allocation of male and female labor from other studies.

As mentioned above, the PIHS does not have information on the time spent by boys in household activities only labor activities. Table A2.1 shows the results from other studies on the relative time spent by males and females in household and directly productive activities. The time spent by males in household activities ranges from one tenth of the time females spend on these activities in the Bangladeshi and (with more variability by age) the Indonesian villages studied, to about half in the Nepalese village studied. If these studies are representative, then males at all ages contribute only a small fraction of the time to these types of activities and so our results may not be too badly biased by the limitation of the data.

The results on directly productive activities are more mixed. The average hours spent by males and females is roughly on par in the Indonesian and Nepalese village studied, but they are as much as five times as high in the Bangladeshi village. As seen in the main text, this disparity is similar to what occurs in rural Pakistan

Of course, the allocation of time across activities depends on the definitions of household and non-household activities used which vary somewhat across the different studies summarized in table A2.1. In the Cain (1980) study, "housework" includes housekeeping, food preparation, shopping, child care, and "other useful and necessary, but not directly productive activities", and "productive" includes animal care, crop production, wage work, trading, fishing, other (handicraft production for consumption or sale, own hut construction, self-employed skilled work, and exchange labor). In the Nag, White and Peete (1980) study "household maintenance" includes child care, household food preparation, firewood collection, and other household maintenance work, and "directly productive" includes animal care, wage labor, handicrafts, labor exchange, rice and garden cultivation, trading, preparation of food for sale, other.

Table A2.1: Ratio of average hours spent by males relative to that of females, by activity from other studies in Asian countries.

	Age group	Type of task:		Total	Number of observations (Male / Female)
		Household Work	Non-Household Production		
Bangladeshi village	10 to 15	0.1	4.7	1.1	165 / 189
	16 to 21	0.1	5.0	1.0	108 / 77
	22 to 59	0.1	4.4	1.0	410 / 441
Indonesian village	9 to 14	0.3	0.4	0.4	17 / 10
	15 to 19	0.1	1.2	0.8	6 / 5
	20 to 29	0.1	1.2	0.7	5 / 9
	30 and over	0.2	1.5	0.8	20 / 19
Nepalese village	9 to 14	0.5	0.7	0.6	82 / 55
	15 to 19	0.6	0.9	0.8	29 / 33
	20 to 29	0.4	1.0	0.9	20 / 28
	30 and over	0.4	1.1	0.8	56 / 110

Source: Bangladesh is adapted from Cain (1980), Indonesia and Nepal from Nag, White and Peet (1980)

Note: See text for definitions of household and non-household work.

Appendix 3: Labor time use of males and females

Figure A3.1 shows the age profiles of reported hours in labor activities (work on family farm, in family enterprise, farm wage work, non-farm wage work) for females and males above ten years old from the PIHS data.

Figure A3.1

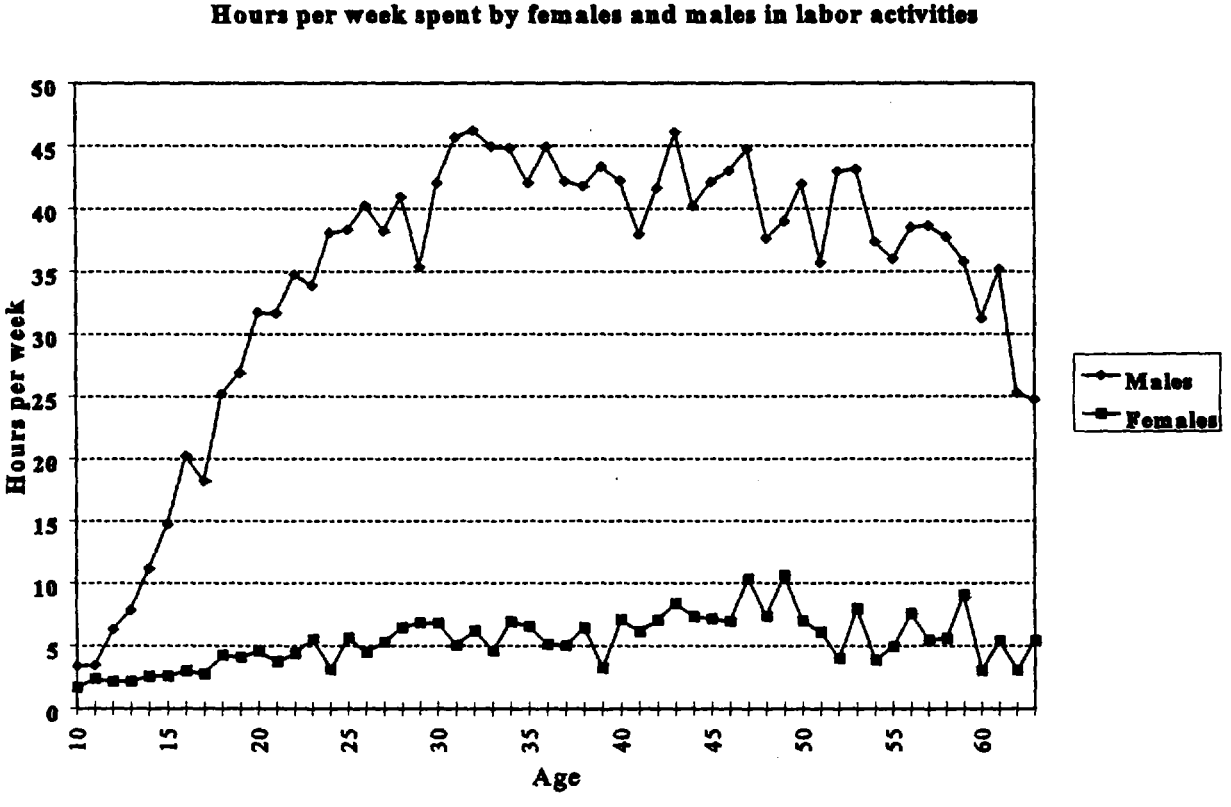

Figure A3.1 is striking in the differential it shows between males and females, even at very young ages. Boys aged fifteen report working on average 15 hours per week in labor activities whereas girls report approximately 2.5 hours per week. By age 25, the average number of hours women report in labor activities reaches a plateau slightly above 5 hours per week. For males, the average number of reported hours per week increases sharply and consistently to about 35 hours at age 25, and peaks at about 45 hours at age 35.

Table A3.1 presents the average hours per week spent by rural males and females between the ages of 10 and 25 in each of the four labor activity categories. Table A3.1 suggests that if females under 25 in rural areas are engaged in labor activities, it is on the family's own farm as the hours reported for females in other labor activities is close to zero. For males the pattern is different as rural males under 25 work initially in the family's own farm, but then work increasingly in family enterprises and for wages on other farms. These results for females are consistent with what was found by Alderman and Chishti (1991) in a study on the simultaneous determination of time in household and market oriented work amongst rural women in Pakistan.

Table A3.1: Average hours per week spent by rural females and males in each labor activity

	Females			Males		
Age Range:	10 to 14	15 to 19	20 to 24	10 to 14	15 to 19	20 to 24
Hours on own farm	2.76	3.92	4.36	5.01	9.72	9.93
Hours in family enterprise	0.21	0.69	0.95	0.84	3.44	6.36
Hours in farm wage work	0.14	0.44	0.55	1.59	8.33	17.40
Hours in non-farm wage work	0.00	0.00	0.00	0.03	0.31	0.31
Total	3.11	5.05	5.86	7.47	21.8	34

Note: Hours in own farm and own enterprise are for past 7 days, hours in farm and non-farm wage work are "usual" hours.

Source: PIHS

Appendix 4: Reduced form equations for fertility

Table A4.1 reports OLS estimates of the determinants of children ever born (CEB) and of the probability of observing a birth in the past 5 years (B5Y), in a reduced form[24]. The function is estimated first for all women (with a dummy variable for rural residence) and then only for rural women. Table A4.2 reports the results when the log of household expenditures per adult is excluded, and when the sample is limited to those in the poorest expenditure group.

Pakistan is a high fertility country. The 1990/91 Pakistan Demographic and Health Survey calculated a total fertility rate of 5.4 and mean number of children ever born to women 40 to 49 of 6.55. Ever married women in the PIHS sample have a total fertility rate of 6.0 in urban areas and 5.5 in rural areas. The mean number of children born to women 40 to 49 is 6.9 in urban areas and 7.1 in rural areas.

Larger total household expenditures per adult are associated with higher CEB when all income groups are pooled. The result is insignificant when only the poorest 50 percentile in the rural areas are considered. Expenditures are associated with a higher probability of B5Y for those women in households which are in the poorest 50th percentile in rural areas. This is consistent with a positive income elasticity for children, especially after controlling for education effects which capture to some extent the value of time of mother's and father's time.

However, since children may contribute to family income, the causal direction is not clear[25]. The findings in the household fertility literature on income have been mixed[26]. When estimated using two-stage least squares (with the head of household's characteristics, housing characteristics, and asset ownership variables as instruments), expenditures have an insignificantly negative effect on CEB for women in rural

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[24] This is called a demand function mostly out of an empirically informed prior that differences in demand account for by far the largest fraction of fertility variation (Pritchett, 1994).

[25] Montgomery and Kouame (1994) have a useful discussion of this causal effect. They explore the exogeneity of expenditures per adult using instrumental variables (IV) in a very similar regression using data from Cote d'Ivoire. They conclude that "...it is disturbingly vulnerable to the selection of instruments and to multicollinearity. In many applications, it is not clear that the method [IV] brings one any closer to the truth". Appendix table 1 shows the results excluding the expenditures variable

[26] Montgomery and Kouame (1994) find a positive and significant effect in Cote d'Ivoire. Benefo and Schultz (1994) use nearly identical regressions and yet find a positive and significant effect in Cote d'Ivoire and a negative and insignificant effect in Ghana. After instrumenting to account for the endogeneity of income the negative effect in Ghana becomes significantly different from zero.

areas[27]. When estimating B5Y and log of expenditures per adult jointly (using the same set of instruments as CEB), expenditures have a negative and insignificant effect on B5Y for women in rural areas. However, a test of the correlation between the errors from the two equations rejects endogeneity. Estimates on the non-income variables are not greatly affected by treating expenditures as endogenous.

The age effects reflect the child bearing cycle: it's quadratic nature captures the fact that CEB, as well as the likelihood of having a birth, increases up to a certain age and then levels off.

Education for the woman is limited to the "ever went to school" variable. This is because there are too few observations on non-zero years of schooling to reasonably identify their effect. For example, among the ever-married rural women aged 14 and over in the CEB regression, 92.4 percent have zero years of schooling, and 98.1 percent have 6 or fewer years of schooling. As is common in the literature, the results show strong negative effects of female education on the number of children ever born. Having gone to school reduces the number of children ever born by a little more than half a child on average. The effect on the probability of birth in the past 5 years is negative, although the parameter estimates are not significantly different from zero. All of the husband's education parameter estimates are insignificantly different from zero in the rural samples.

The Punjab province is the excluded provincial dummy variable, hence the results indicate that women in the Sindh region have slightly lower fertility, and those in the NWFP have slightly higher fertility than in the Punjab region. Surprisingly, rural women have fewer children, after correcting for the other factors.

[27] The two-stage least squares and joint-estimation results are not reported here but are available from the authors.

Table A4.1: OLS estimates of the determinants of children ever born for ever married women aged 14 and over, and mean change in the probability of birth in the past 5 years (from Probit estimation) for ever married women aged 19 and over.

	Birth in the Past 5 Years		Children Ever Born	
	Rural and Urban	Rural only	Rural and Urban	Rural only
Household expenditures per adult, natural log	0.021 (0.062)	-0.002 (0.889)	0.158 (0.005)*	0.252 (0.001)*
Age in years	0.084 (<0.001)*	0.088 (<0.001)*	0.555 (<0.001)*	0.570 (<0.001)*
Age in years, squared	-0.002 (<0.001)*	-0.002 (<0.001)*	-0.005 (<0.001)*	-0.005 (<0.001)*
1=Ever went to school (†)	-0.008 (0.678)	-0.026 (0.402)	-0.831 (<0.001)*	-0.519 (0.006)*
1=Spouse information available (†)	-0.295 (0.244)	-0.211 (0.405)	0.520 (0.572)	0.116 (0.907)
Spouse years of schooling	0.004 (0.350)	-0.001 (0.877)	0.070 (0.002)*	0.022 (0.544)
Spouse years of schooling, squared	-0.001 (0.028)*	-0.0003 (0.603)	-0.010 (<0.001)*	-0.004 (0.195)
1=Sindh region (†)	-0.203 (<0.001)*	-0.252 (<0.001)*	0.161 (0.047)*	0.157 (0.165)
1=NWFP region (†)	0.068 (0.001)*	0.025 (0.325)	0.372 (<0.001)*	0.238 (0.082)
1=Baluchistan region (†)	-0.063 (0.006*)	-0.069 (0.027)*	0.116 (0.367)	-0.131 (0.491)
1=Rural community (†)	-0.031 (0.025)*		-0.132 (0.064)	
Constant			-9.007 (<0.001)*	-9.622 (<0.001)*
Summary statistics				
N	5833	3030	6085	3184
R-Squared (pseudo R-Squared for B5Y)	0.3132	0.3096	0.4401	0.4405
Mean of dependent variable	0.456	0.439	5.03	5.02

Notes: (†) indicates variables for which parameter estimates reported in birth in the past 5 years model are for change in the variable from 0 to 1. P-values (of probit parameter estimates) are reported in parenthesis, (*) indicates significantly different from zero at the 95% level

Source: PIHS

Table A4.2: OLS estimates of the determinants of children ever born for ever married women aged 14 and over, and mean change in the probability of birth in the past 5 years (from Probit estimation) for ever married women aged 19 and over.				
	Birth in the Past 5 Years		Children Ever Born	
	Rural only		Rural only	
	All	Poorest 50th percentile (#)	All	Poorest 50th percentile (#)
Household expenditures per adult, natural log		0.074 (0.014)*		0.075 (0.676)
Age in years	0.088 (<0.001)*	0.074 (<0.001)*	0.580 (<0.001)*	0.548 (<0.001)*
Age in years, squared	-0.002 (<0.001)*	-0.001 (<0.001)*	-0.005 (<0.001)*	-0.005 (<0.001)*
1=Ever went to school (†)	-0.027 (0.390)	-0.043 (0.303)	-0.457 (0.016)*	-0.627 (0.038)*
1=Spouse information available (†)	-0.212 (0.403)	-0.194 (0.430)	0.165 (0.869)	-0.298 (0.804)
Spouse years of schooling	-0.001 (0.875)	0.0001 (0.994)	0.264 (0.468)	0.008 (0.881)
Spouse years of schooling, squared	-0.0003 (0.602)	-0.001 (0.499)	-0.004 (0.205)	-0.002 (0.644)
1=Sindh region (†)	-0.252 (<0.001)*	-0.249 (<0.001)*	0.173 (0.125)	0.089 (0.553)
1=NWFP region (†)	0.025 (0.329)	-0.002 (0.943)	0.318 (0.018)*	0.123 (0.544)
1=Baluchistan region (†)	-0.070 (0.026)*	0.004 (0.928)	-0.072 (0.707)	-0.140 (0.629)
1=Rural community (†)				
Constant			-8.224 (<0.001)*	-7.821 (<0.001)*
Summary statistics				
N	3030	1631	3184	1735
R-Squared (pseudo R-Squared for B5Y)	0.3096	0.3536	0.4386	0.4719
Mean of dependent variable	0.439	0.405	5.02	4.81
Notes: (#) Poorest 50th percentile as measured by household expenditures per adult (†) indicates variables for which parameter estimates reported in birth in the past 5 years model are for change in the variable from 0 to 1. P-values (of probit parameter estimates) are reported in parenthesis, (*) indicates significantly different from zero at the 95% level.				
Source: PIHS				

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